Material Mechanics and Circular Economy: Study of Compressive Strength of Concrete Incorporating Molasses Waste as an Environment Friendly Replacement for Cement

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Abstract

The project's goal was to determine whether molasses waste, a byproduct of sugar manufacturing, could replace cement in concrete in a sustainable and economical manner. The study concentrated on analyzing concrete specimens' performance at various curing ages and measuring the compressive strength of those specimens with varying molasses waste replacement percentages. For compression tests six samples were casted for each replacement ratio, and compression tests were carried out on two samples at 7 days, 14 days, and 28 days. Replacement ratios of 0.25%, 0.5%, 0.6%, 0.75%, 1%, and 2% were taken into consideration. Notably, the average compressive strength significantly increased to 40 MPa with the addition of molasses waste at a replacement ratio of 0.25%, demonstrating a beneficial effect on strength improvement. The average compressive strength dropped somewhat, with a value of 38 MPa at 28 days, when the replacement ratio rose to 0.5%. A replacement ratio of 0.6%, on the other hand, revealed a significant drop in average compressive strength to 17.17 MPa, indicating a detrimental impact on strength development. Future study recommendations from the experiment include examining how variables like the water-to-cement ratio and curing circumstances affect the performance of molasses waste in concrete. To evaluate the long-term durability characteristics and financial viability of using molasses waste as a cement substitute, cost-benefit assessments and long-term durability studies are also advised.

Keywords: Manufacturing, Molasses Waste, Cement Industry.

Introduction

Due to excessive cement consumption in the manufacturing of concrete, the construction sector has recently had to deal with growing environmental issues. Energy-intensive cement manufacture results in significant carbon dioxide emissions. In addition, issues about sustainability and long-term profitability are raised by the loss of natural resources used to make cement.

Researchers and engineers have been looking towards substitute materials that may partially or entirely replace cement in concrete without affecting its performance and durability to address these issues. Molasses waste, a byproduct of the sugar industry, is one such substance. Molasses waste is often thrown away as a waste product, which causes problems with the environment and disposal. However, it has a number of qualities that might make it a contender to replace cement in concrete. Our senior project's main objective is to assess how well molasses waste performs as a viable cement substitute in the manufacture of concrete.

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Problem Statement

Significant environmental effects are caused by the production of cement for the manufacture of concrete, including substantial energy use and greenhouse gas emissions. Concerns about climate change are exacerbated by the cement industry's significant worldwide carbon dioxide emission contribution. As a by-product, the sugar processing industry produces a sizable amount of waste molasses. This garbage presents environmental difficulties since it needs sustainable disposal methods.

The difficulty is in coming up with realistic solutions for both the problem of reducing the amount of cement used in the manufacturing of concrete and the problem of what to do with all the surplus molasses waste produced by the sugar industry. To reduce its negative environmental effects and advance sustainable waste management techniques, molasses waste must be properly managed and used. This study attempts to address these urgent challenges by investigating the use of molasses waste as a cement substitute material in concrete.

The goal of the study is to determine whether utilizing molasses waste in place of cement in concrete can result in concrete that is stronger, easier to work with, and more durable. It tries to support the idea that adding molasses waste to concrete can have the twin benefits of cutting down on cement usage and resolving environmental issues related to cement manufacture.

By providing information about the use of molasses waste as a workable substitute in the creation of environmentally friendly concrete, this study seeks to support sustainable building practices. The results will aid in the establishment of more environmentally friendly waste management techniques as well as environmentally friendly building materials.

Objectives

This study's main goal is to assess how well molasses waste performs as a concrete alternative for cement. The study specifically seeks to:

i. To determine the optimal replacement ratio of molasses waste to cement for maximum strength of the concrete.
ii. To compare the compressive strength of concrete made with molasses waste and traditional cement.
iii. To examine the effect of molasses waste on workability of the concrete.
iv. Analyze the environmental benefits and drawbacks of utilizing molasses waste in concrete production.

Research Gap

It has become more popular to use molasses waste in concrete manufacturing as a sustainable material. But there are still areas of research that require improvement. There aren't many experimental findings with molasses waste-based concrete. In-depth examinations are required to assess its durability, workability, and strength. In order to guarantee the long-term performance of concrete made from molasses waste, durability qualities must be evaluated while taking degradation and environmental consequences into account.

To maximize efficacy and achieve desired performance and structural integrity, the best mix proportions must be determined. To address possible difficulties such delayed strength development and cracking, it is necessary to thoroughly examine the long-term behavior and stability of molasses waste-based concrete. Comprehensive analysis is required to determine the economic viability and sustainability advantages of molasses waste-based concrete, including cost-effectiveness and environmental impact. The potential of molasses waste as a sustainable alternative will be unlocked by filling these shortcomings. It is essential to do extensive research, durability assessments, the best mix design, long-term studies, and economic evaluations.

Literature Review

In concrete used in the construction sector, molasses is being examined as a possible cement substitute. This is due to the fact that molasses, a product of the sugar industry, has several advantages and benefits for the environment. We may encourage sustainable building practices by replacing conventional cement components with molasses. Sugars included in molasses can aid in enhancing the durability and workability of concrete. Additionally, it contains organic chemicals that facilitate the hydration process and gradually increase the concrete's strength. By substituting molasses for cement, which is known to have a substantial negative impact on the environment, less cement must be produced.

Molasses is a thick, dark, and sweet syrup-like substance that is produced as a byproduct of the sugar manufacturing process. As a byproduct of sugarcane or sugar beet processing, molasses is created. There are various crucial phases in the manufacturing process. Overall, the steps in the molasses production process include extraction, clarifying, evaporation, crystallization, and separation, each of which is essential to the creation of the finished product.

Studies on the use of molasses as a cement substitute in concrete have been done, with an emphasis on how it affects compressive strength. Concrete's shear capacity can only be calculated using its compressive strength. The best molasses dose and its effects on hydration, microstructure, and long-term durability have been shown by these experiments. The study proposes creative ways to improve concrete qualities while taking environmental considerations into account, which supports sustainable building methods.

The goal of Shahidkha (2017) study was to examine the use of molasses as a time-delaying additive in concrete. In this study, the setting times of molasses-based concrete were tested at three different dosages of cement content. It was shown that the initial and final setting times are both greatly lengthened by the addition of molasses. Additionally, even though the strength increased significantly, there was no negative impact on it. The initial and final setting times of high-performance concrete were found to be much longer when molasses is added.

By-products of the manufacture of pig iron and steel, such as molasses and steel slag, were the focus of Balram and Panchal (2018) investigation on the best approach to incorporate them into concrete This study compares concrete with additions of molasses and steel slag with constant water-to-cement ratios and additions of slag and molasses respectively. In tests, it was shown that adding up to 0.90 percent of molasses and 75% of steel slag boosted the compressive strength of the concrete. This is due to the fact that molasses plays a vital role in promoting ideal circumstances for the uniformity of concrete density by containing large amounts of chemicals that form macromolecular micelles. Additional dosage increases cause the surface materials to separate, the volume of gels created by hydration to significantly increase, and the formation of faults in the microstructure of concrete, reducing its strength. When this optimum value is applied, it will produce concrete that is more robust and durable than typical concrete. It is demonstrating how effectively the leftovers from sugar companies' distilleries may change the characteristics of concrete.

Kasses (2019) investigates the usage of molasses as a concrete addition. This study sought to develop a specific molasses mix ratio as a concrete mix retarder in addition to identifying the characteristics of C-25 Concrete. Molasses was found to significantly extend setting time, slow down the rate of strength growth in young concrete, and boost compressive strength in older concrete. According to the study, adding molasses to cement paste might make it take the compound at least 380 minutes longer to cure.

Molasses doses of 0.05 to 0.075% result in a beneficial maximum delay of the first setting time that complies with ASTM C494 regulation. On the other hand, the correct final setting time is achieved with a molasses dose of between 0.025 and 0.05%. The workability of concrete containing molasses increases proportionally as the molasses percentage increases due to the prolonged period of the stiffening process of concrete caused by molasses as a retarder admixture; this could be used to decrease the amount of water to increase the compressive strength of concrete.

In this study, the workability and compressive strength of concrete from southern Maharashtra that contains fly ash and sugarcane molasses were investigated by Bhide et al. (2017) and Ahmed et al. (2017). Molasses was added to cement that had been curing for 7, 28, and 56 days, and the effects of doing so at weight-based quantities of 0.1%, 0.15%, 0.2%, and 0.25% were studied. All the specimens were demolded after 24 hours, although it took 48 hours for those with molasses doses of 0.25 and 0.2% to do so. Concrete's capacity to slow down is demonstrated by the delayed setting of the concrete. After 7 days, the strength of concretes with varied molasses doses showed a little improvement when compared to concrete without molasses. The results of the compressive strength test showed a significant improvement in strength for 0.15% dosage. With an increase in molasses dosage from 0.1% to 0.25%, the slump values were seen to rise linearly.

Mechanical properties like split tensile strength and compressive strength are studied by Babar et al. (2019). A number of variables, such as water absorption, absorptivity coefficient, chloride penetration, and acid attack resistance, are used to evaluate each mix's durability. The testing results show that molasses may be used to enhance RAC's poor mechanical and durability performance. The inclusion of molasses reduced the quantity of water required to generate a uniform product, making RAC and NAC easier to handle. The compressive strength and split tensile strength of RAC treated with 0.5% molasses improved by up to 10-12% and 11-19%, respectively. When RAC was attacked by acid, the most significant decrease in water absorption, absorptivity, chloride penetration, and mass loss was shown at 0.1-0.5% molasses. When the amount of molasses is changed, RAC and NAC behave similarly.

Workability begins to decline at a molasses dosage of 0.01%. This is related to an increase in water use to preserve the uniformity of the norm. Larger dosages (>0.05%) are reported to significantly improve workability, though. When the molasses dose is altered, the NAC and RAC levels show a similar pattern. RAC is far less useful than NAC at any typical molasses dosage. Even when utilized in RAC, pre-soaked RCA is still less useful than the NAC. This is explained by the variance in angularity and roughness between RCA and NCA. The main issue is how usable RAC's application is. At dosages of 0.1%, 0.5%, and 1%, the workability of RAC rises by 22%, 56%, and 76%, respectively the workability of NAC increases by 18%, 49%, and 71% at doses of 0.1%, 0.5%, and 1%, respectively. Higher dosages of combinations become more workable due to the sugar component of molasses, which acts as a surface-active agent. Surface-active chemicals increase the quantity of free water in cement paste, making concrete more workable. A larger molasses dose results in less water being used at a constant water-to-cement ratio, which considerably enhances workability. Fresh density is somewhat decreased by 0.01% molasses, but significant gains in both NAC and RAC are seen at greater dosages. At all dosages, the fresh density of RAC is lower than that of NAC. This is due to the fact that RAC has a lower density than NAC because, for an equivalent volume, RCA's weight is always smaller than NCA's. With increased molasses dosage, RAC and NAC's fresh density improved, which can be attributed to their improved workability.

The use of cane molasses as a water-saving additive to recycled aggregate concrete is looked at in this study by Rashid et al. (2019). The disadvantages of using recycled material alone in concrete may be reduced by combining recycled aggregate with molasses. The fresh characteristics of cement pastes and recycled aggregate concrete were examined in this study using a range of cane molasses doses (0.25–0.75% by weight of cement). Compressive strength, splitting tensile strength, and shear strength—three essential characteristics of hardened concrete—were tested for up to 365 days. X-ray diffraction analysis was also performed at all testing ages. It was also determined via experiments and analytical discussions that adding molasses up to 0.25% enhanced the mechanical performance of recycled aggregate concrete. The

findings obtained indicated that the use of molasses in concrete with recycled particles is promising, provided dosage restrictions are taken into consideration.
In this study, "CC- 00" stands for recycled aggregate concrete without molasses, whereas "CC-25," "CC-50," and "CC-75" show the molasses dosage in recycled aggregate concrete as 0.25 percent, 0.50 percent, and 0.7 percent, respectively.
Figure below showed that the use of molasses had a beneficial impact on the compressive strength of concrete, beginning at an early curing age of seven days. Concrete specimens made using recycled aggregate and 0.25–0.75% molasses showed greater compressive strength than the reference specimen. Compared to CC-50, CC-75, and the control specimen (CC-00), molasses-contained concrete (CC-25) demonstrated greater strength. All concrete specimens' compressive strengths significantly increased between 28 and 365 days.
The tensile strength of concrete specimens with 0.25% molasses (CC-25) was somewhat higher at 7 days than it was at the same time for the reference specimen (CC-00), and the same general trend was seen for tensile strengths after 365 days. After 365 days, CC-00 showed poorer splitting tensile strengths than dosages of molasses of 0.50 to 0.75 percent. This demonstrates that the rate of molasses would not be positively impacted by the long-term tensile strength over the ratio of 0.25%. Overall, the results of the splitting tensile strength tests showed no discernible trend as the molasses dose increased. The strength of the aggregates, the kind and volume of the bonds produced between them, and the micro cracking, among other elements that affect tensile strength, all played a part in this.

Methodology

This chapter presents the method employed inside the project for the replacement of cement with molasses waste in concrete. The goal of this research is to discover the feasibility of utilizing molasses waste as a partial substitute for cement in concrete manufacturing, aiming to lessen environmental influences and sell sustainable practices in the production enterprise. The bankruptcy affords a detailed overview of the experimental setup, materials used, and the technique followed throughout the undertaking.

Concrete Mix Design

Mix design percentage refers back to the technique of determining the precise mixture of components to supply a concrete mix with preferred homes. It includes selecting the perfect proportions of cement, aggregates, water, and admixtures to achieve the favored energy, workability, sturdiness, and other characteristics of the concrete.
The correct proportion of cement, aggregates, and water is vital for accomplishing the preferred energy and durability of the concrete. Mistaken proportions can lead to vulnerable or brittle concrete that could fail underneath load or go to pot fast over time.
The percentage of water in the mix determines the workability or consistency of the concrete. The combination must be fluid enough to be without problems located and compacted, however now not excessively watery. The right balance of water guarantees right workability, making it simpler to shape, end, and reap proper compaction.
Via optimizing the combination proportions, it's miles feasible to acquire the required houses whilst minimizing the usage of cement and different steeply-priced materials. This can help lessen fees without compromising the quality and performance of the concrete.
To decide the mix layout proportion, different factors want to be considered, which include the favored electricity, workability, exposure situations, kind and size of aggregates, and any unique task necessities. Numerous methods and recommendations, which include the ACI (American Concrete Institute) approach or the British requirements (BS) approach, are to be had to assist engineers and urban technologists in figuring out the right blend proportions for a given utility.
Table 1 shows the ingredients mass for casting of 6 molds of size six cubic inches.

Table 1: Mix Design Proportion

Molasses	Molasses	Cement	Coarse Aggregate	Fine Aggregate	W/C Ratio
%	gm	kg	kg	kg	
0	0	11.54	26.8	21.9	0.505
0.25	28.85	11.51	26.8	21.9	0.505
0.5	57.7	11.48	26.8	21.9	0.505
0.75	86.55	11.4	26.8	21.9	0.505
2	230.8	11.31	26.8	21.9	0.505

Figure 1: Vibrating Table

Figure 2: Mold

Figure 3: Drum Mixer

Figure 4: Denison Compression Testing Machine

Material Collection

Molasses waste refers to the byproducts or residues left over from the production of molasses. Molasses is a viscous dark syrup obtained by processing sugar cane or sugar beet. It is often used as a sweetening or flavoring agent in various foods [10]. Molasses waste was obtained from SW Sugar Factory, Sillanwali.

These are larger particles, typically 5 mm (0.2 in) to 20 mm (0.8 in) in diameter.

Figure 5: Molasses Waste	Figure 6: Coarse Aggregate	Figure 7: Sand
		

Experimentation

Concrete Mixing

Set up the concrete mixer or prepare a flat and clean mixing area.
Measure the required amount of cement, sand, and aggregates according to the mix design.
Thoroughly dry mix the cement, sand, and aggregates until they are uniformly blended.
Gradually add water while continuously mixing the dry materials.
Continue mixing until the concrete achieves a uniform consistency, free from lumps, and the desired workability. Mixer used during research is showed in figure.

Filling the Cube Molds

Transfer the mixed concrete to the cube molds in equal layers.
Compact each layer using a vibrating table or vibrating poker. The vibrations help to eliminate air voids and ensure proper consolidation of the concrete. Vibrating table is showed in figure 1.
Repeat the process until the molds are completely filled, leaving a slight excess of concrete above the mold's top surface.

Finishing and Curing

a. Smooth the surface of the concrete using a trowel or float.
b. Mark the identification details on each cube mold, such as the date of casting, mix details, and unique identifiers.
c. Cover the filled molds with a polythene sheet or wet burlap to prevent moisture loss and promote proper curing. Curing process is showed in figure 7.
d. Allow the concrete to cure undisturbed in a controlled environment, typically in a curing room or under a wet curing tank, for a specified period (usually 28 days)

Demolding

a. After the curing period, carefully remove the cube molds without causing any damage to the cubes.
b. Clean the cubes from any loose particles or excess material.
c. Conduct the compressive strength test on the cubes using a suitable testing machine, following the relevant standards and protocols.

Compression Test

The compression test of a poured concrete cube is a method used to determine the compressive strength of concrete. During the test, a compressive force is applied to the concrete cube until it fails. The cube was placed in a compression testing machine (general testing machine). The machine applies progressively increasing compressive force to the cube until it fails. The force is applied at a constant rate until the cube breaks or shows significant deformation. During the test, the testing machine records the maximum load applied to the cube. This is the load at which the cube fails or its load capacity is significantly reduced. Load is measured in units of force, such as tons or pounds (lbs). Compression test results are usually reported as the average compressive strength of three cubes tested from the same lot or sample. The results show the ability of concrete to withstand compressive forces. Testing machine is showed in figure 9.

Figure 8: Curing

Figure 9: Curing

Figure 10: Denison Compression testing machine

Results Analysis and Discussion

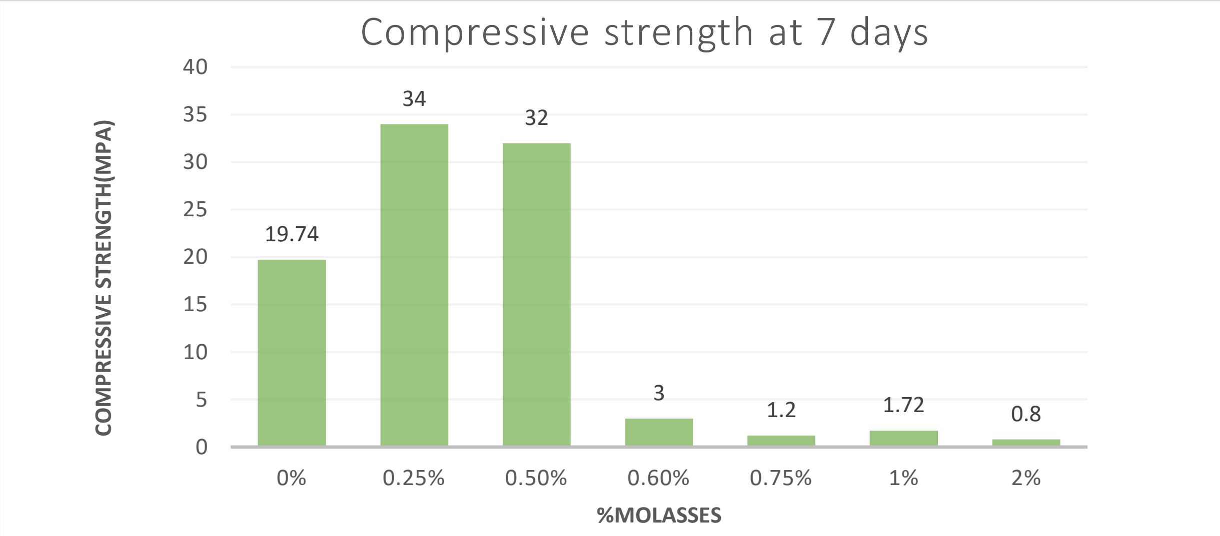
This chapter presents the results and analysis of the experimental investigation conducted to evaluate the performance of molasses waste as a cement replacement in concrete. The study focused on the compressive strength of concrete specimens with different replacement ratios of molasses waste. The mix design proportion ratio used was 1:1.89:2.32, and the temperature during curing ranged from 25°C to 30°C. Compression tests were carried out on samples at 7 days, 14 days, and 28 days. We casted 6 concrete cube molds of concrete for each molasses replacement ratio, except for the 0.75% and 1% replacements, which had five samples due to unavailability of cube molds during casting.

The average compressive strength results obtained from the compression tests conducted on the concrete specimens at 7 days, 14 days, and 28 days. The table 1, 2 and 3 includes the replacement ratios of molasses waste used in the study and their corresponding average compressive strength values at 7 days, 14 days, and 28 days.

Table 2: Average Compressive Strength Results at 7 Days

Replacement ratio	Compressive Strength (MPa)
0% (Control Sample)	19.74
0.25%	34
0.5%	32
0.6%	3
0.75%	1.2
1%	1.72
2%	0.8

Figure 11: Compressive Strength vs Molasses at 7 days 0.6% molasses replacement achieved



The compressive strength results at 7 days for different molasses replacement ratios are presented in table 1. The control sample, without any molasses replacement, exhibited an average compressive strength of 19.74 MPa. The addition of 0.25% molasses replacement resulted in a significant increase in compressive strength to 34 MPa. Similarly, the samples with 0.5% and compressive strengths of 32 MPa and 3 MPa, respectively. However, a notable decrease in compressive strength was observed for the samples with higher molasses replacement percentages. The 0.75% molasses replacement resulted in a compressive strength of 1.2 MPa, while the samples with 1% and 2% molasses replacement exhibited compressive strengths of 1.72 MPa and 0.8 MPa, respectively.

These results suggest that a small percentage of molasses replacement (0.25%) positively influenced the compressive strength of the concrete at 7 days, resulting in a significant improvement compared to the control sample. This can be attributed to the presence of certain chemical compounds present in molasses that may enhance the early-stage strength development of concrete. However, as the molasses replacement ratio increased beyond 0.25%, the compressive strength decreased.

The decrease in compressive strength with higher molasses replacement percentages may be attributed to several factors. One possible reason could be the dilution effect, where the molasses, being a viscous and non-cementitious material, displaces cement particles and reduces the overall strength. Additionally, the presence of impurities or variations in the composition of molasses waste may negatively affect the hydration process, resulting in weaker bonds and lower compressive strength. Moreover, excessive molasses content might hinder the proper formation of calcium silicate hydrate (C-S-H) gel, which is responsible for the strength development in concrete.

These findings highlight the importance of careful consideration when selecting the optimal molasses replacement ratio in concrete. While a small percentage of molasses replacement (0.25%) showed promising results in terms of improved compressive strength, higher replacement ratios led to decreased strength values. Further investigations are necessary to better understand the specific chemical interactions between molasses waste and cement, as well as the long-term effects on the durability and mechanical properties of the concrete.

It is worth noting that these results in figure 1 are specific to the 7-day testing period. Longer-term testing, such as 28 days or beyond, is essential to evaluate the ultimate compressive strength and the potential for strength gain over time.

Table 3: Average Compressive Strength Results at 14 Days

Replacement ratio	Compressive Strength (MPa)
0% (Control Sample)	25
0.25%	37
0.5%	35
0.6%	7.3
0.75%	3.5
1%	2.3
2%	1.3

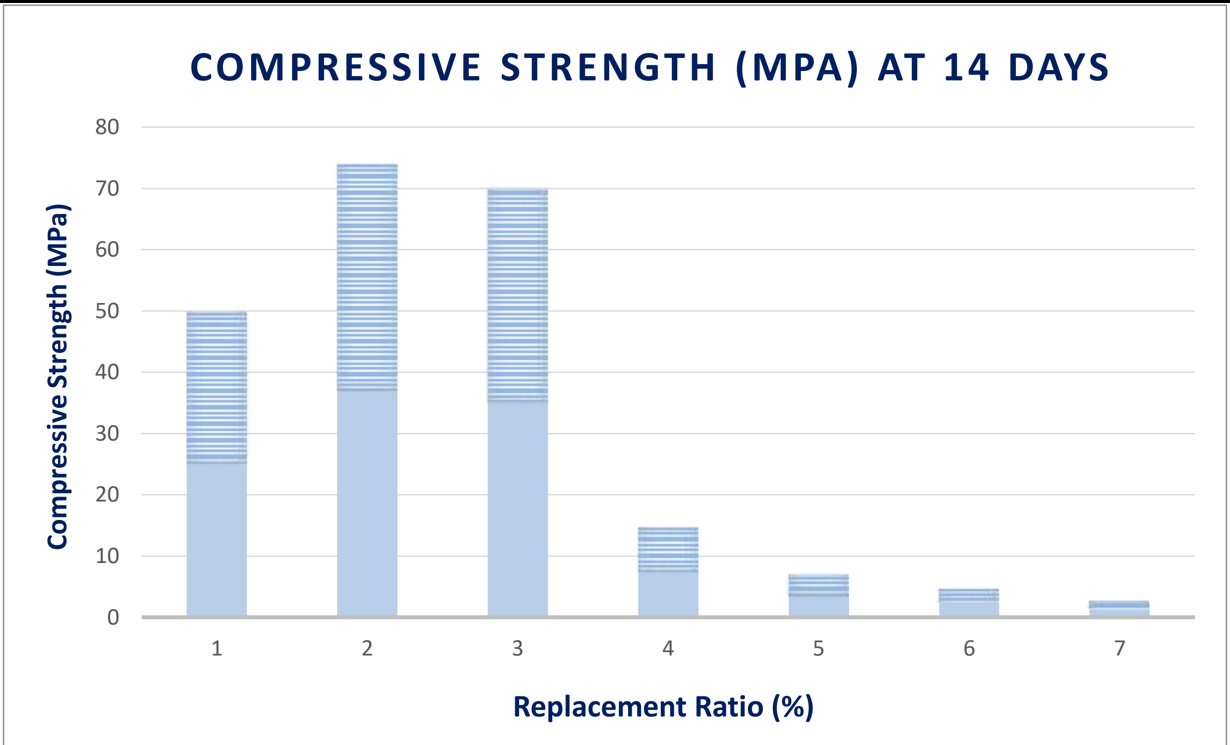


Figure 12: Compressive Strength vs Molasses at 14 days

The average compressive strength results at 14 days for different molasses replacement ratios are summarized in table 2. The control sample, without any molasses replacement, exhibited an average compressive strength of 25 MPa. The addition of 0.25% molasses replacement resulted in a significant increase in compressive strength to 37 MPa. Similarly, the samples with 0.5% and 0.6% molasses replacement achieved compressive strengths of 35 MPa and 7.3 MPa, respectively. However, a significant decrease in compressive strength was observed for the samples with higher molasses replacement percentages. The 0.75% molasses replacement resulted in a compressive strength of 3.5 MPa, while the samples with 1% and 2% molasses replacement exhibited compressive strengths of 2.3 MPa and 1.3 MPa, respectively.

These results indicate that the addition of a small percentage of molasses replacement (0.25%) continued to have a positive impact on the compressive strength of the concrete at 14 days, resulting in a notable improvement compared to the control sample. This suggests that the early strength gain observed at 7 days may continue to develop over time. However, as the molasses replacement ratio increased beyond 0.25%, the compressive strength decreased.

The decrease in compressive strength with higher molasses replacement percentages at 14 days follows a similar trend to the 7-day results. This may be due to factors such as the dilution effect, variations in molasses composition, and potential hindrance of proper hydration and bond formation in the concrete. The presence of impurities or inconsistent chemical properties in molasses waste could also contribute to the observed decrease in strength.

These findings highlight the importance of carefully selecting the appropriate molasses replacement ratio to achieve the desired compressive strength. While a small percentage of molasses replacement (0.25%) showed favorable results in terms of improved compressive strength, higher replacement ratios led to diminished strength values. Further investigation is necessary to gain a deeper understanding of the underlying mechanisms and the long-term effects of molasses waste on the durability and mechanical properties of concrete.

Table 4: Average Compressive Strength Results at 28 Days

Replacement ratio	Compressive Strength (MPa)
0% (Control Sample)	29
0.25%	40
0.5%	38
0.6%	17.17
0.75%	4.5
1%	3.5
2%	2.5

Figure 13: Compressive Strength vs Molasses at 8 days

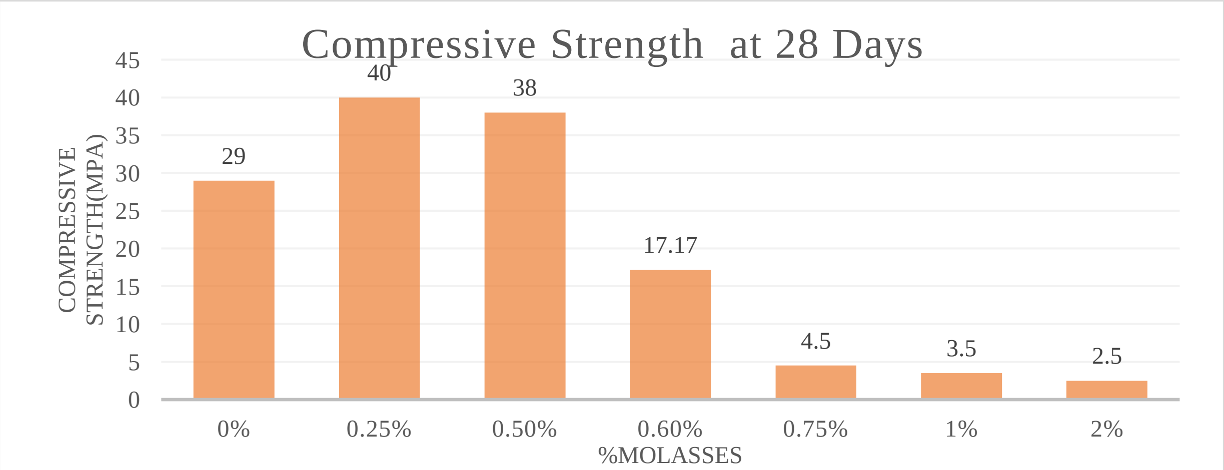


Table presents the average compressive strength results at 28 days for different replacement ratios of molasses waste in concrete. The replacement ratios range from 0% (control, no molasses waste) to 2%. Each value in the "Compressive Strength (MPa)" column represents the average compressive strength obtained from multiple samples tested under the given replacement ratio.

The control sample, with no molasses waste replacement, had an average compressive strength of 29 MPa at 28 days. This value serves as a reference for comparing the effects of molasses waste replacement on concrete strength.

At a 0.25% replacement ratio, the average compressive strength significantly increased to 40 MPa. This indicates that the incorporation of a small amount of molasses waste positively influenced the strength development of the concrete.

For the 0.5% replacement ratio, the average compressive strength was slightly lower at 38 MPa. Although there was a slight reduction in strength, it remained relatively higher than control value, suggesting that a moderate replacement of cement with molasses waste had a minimal impact on strength.

At a 0.6% replacement ratio, there was a notable decrease in average compressive strength, with the value dropping to 17.17 MPa. This reduction in strength indicates that beyond a certain replacement level, the performance of the concrete was significantly affected.

Further increasing the replacement ratios to 0.75%, 1%, and 2% resulted in substantial declines in average compressive strength. The strengths obtained were 4.5 MPa, 3.5 MPa, and 2.5 MPa, respectively, at 28 days. These values indicate a considerable loss of strength compared to the control sample, suggesting that higher replacement ratios of molasses waste had a detrimental effect on the concrete's strength development.

In summary, the table demonstrates the varying effects of different replacement ratios of molasses waste on the compressive strength of concrete. The results in figure above indicate that a replacement ratio of 0.25% and 0.5% led to increased strength, while higher replacement ratios (0.6% and above) resulted in reduced strength.

Discussion

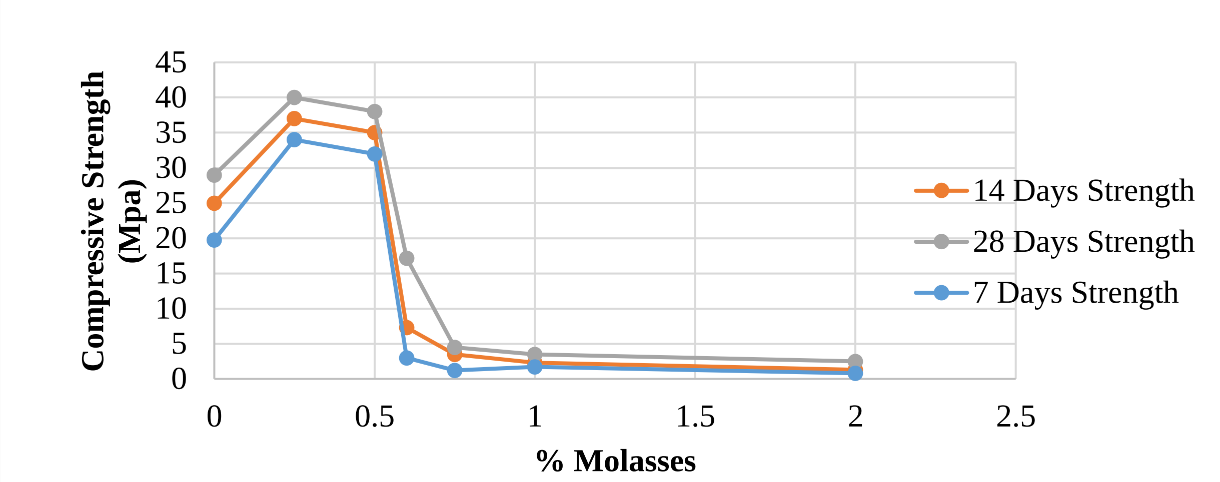
Effect of Molasses Waste on Compressive Strength

The results in figure 13 indicate that the addition of a small percentage of molasses waste (0.25%) positively influenced the compressive strength of the concrete at all testing periods (7 days, 14 days, and 28 days). This early strength gain can be attributed to the presence of certain chemical compounds in molasses that enhance the early-stage strength development of concrete.

The optimal replacement ratio for molasses waste appears to be 0.25% as it consistently yielded higher compressive strength values compared to the control sample at all testing periods. This suggests that a moderate replacement of cement with molasses waste can improve the strength of the concrete.

However, as the molasses replacement ratio increased beyond 0.25%, the compressive strength decreased. This decrease can be attributed to factors such as the dilution effect, variations in molasses composition, and potential hindrance of proper hydration and bond formation in the concrete.

Figure 14: Compressive Strenght Vs Molasses



Influence of Molasses Waste Composition

Impurities and Inconsistent Chemical Properties: The decrease in compressive strength with higher molasses replacement ratios may be due to the presence of impurities or inconsistent chemical properties in molasses waste. These impurities and variations in composition could interfere with the hydration process and hinder the formation of strong bonds, resulting in weaker concrete.

Considerations for Practical Application

Optimal Molasses Replacement Ratio: The findings emphasize the importance of carefully selecting the appropriate molasses replacement ratio to achieve the desired compressive strength. A replacement ratio of 0.25% showed favorable results in terms of improved compressive strength, while higher replacement ratios led to diminished strength values. Engineers and researchers should consider this optimal replacement ratio when using molasses waste as a cement replacement material in concrete applications.

Long-Term Performance Evaluation: The results presented in this study are specific to the testing periods of 7 days, 14 days, and 28 days. To fully assess the potential of molasses waste as a cement replacement material, longer-term testing, such as evaluating the compressive strength at 56 days or beyond, is recommended. This will provide a more comprehensive understanding of the strength development and durability of concrete with molasses waste.

Other Concrete Properties: While compressive strength is a crucial parameter, it is essential to evaluate other concrete properties, such as workability, durability, and the influence of molasses waste on different aspects of performance. These properties play a significant role in determining the overall suitability of molasses waste as a cement replacement material in practical applications.

Findings

The tests' average compressive strength values led to the following significant discoveries:

1. The average compressive strength at 28 days dramatically increased to 40 MPa at a replacement ratio of 0.25%, demonstrating the benefit of using a tiny quantity of molasses waste in place of cement.
2. The average compressive strength for the 0.5% replacement ratio was marginally lower than the control sample at 38 MPa demonstrating little effect on strength.
3. The average compressive strength dramatically fell to 17.17 MPa at the 0.6% replacement ratio, indicating that the performance of the concrete was significantly impacted above that level of replacement.

4. Average compressive strength significantly decreased with replacement ratios of 0.75%, 1%, and 2%, with values of 4.5 MPa, 3.5 MPa and 2.5 MPa respectively, at 28 days. In comparison to the control sample, these results showed a significant reduction in strength.

Conclusion

Numerous conclusions can be drawn concerning the performance of molasses waste as a cement replacement in concrete:

- A 0.25% substitute ratio of molasses waste ended in a vast boom in compressive energy, indicating that incorporating a small quantity of molasses waste can enhance the strength development of concrete.
- Alternative ratios up to 0.5% showed a minimum impact at the compressive energy, suggesting that a slight substitute stage of molasses waste can be applied without compromising the general power of the concrete.
- However, replacement ratios beyond 0.5% caused a widespread reduction in compressive power, indicating that better substitute tiers have a detrimental effect on the power development of the concrete.
- The decline in power at better replacement ratios can be attributed to elements together with the dilution of cementitious materials, inadequate hydration, and potential interference with the formation of calcium silicate hydrates.

Recommendations

Even as this take a look at gives valuable insights into the performance of molasses waste as a cement alternative in concrete, there are possibilities for in addition studies on this region. Some tips for destiny investigations consist of:

- Exploring the influence of different parameters, consisting of water-to-cement ratio and curing conditions, on the overall performance of molasses waste as a cement replacement in concrete.
- Investigating the lengthy-time period results of molasses waste on the durability and other mechanical properties of concrete, beyond compressive electricity.
- Assessing the economic feasibility and sustainability aspects of making use of molasses waste as a cement substitute in large-scale concrete production.
- Investigating the capability utilization of molasses waste together with different supplementary cementitious materials to optimize the performance of concrete.

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